Toronto
General specifications for
bridges

CITY OF TORONTO

General Specifications for Bridges.

SECTION A.

GENERAL.

1. Unless otherwise specified, all bridges built for the City of Toronto shall be designed and constructed in accordance with these specifications.

Special specifications.

2. Special specifications will generally be issued for each proposed bridge, giving type of bridge, general dimensions, and such other information as may be necessary for the Contractors to tender. Such special specifications shall govern on any point wherein they may conflict with these general specifications.

Drawings.

3. Any drawings that may accompany the specifications referred to in the preceding clause shall form a part of such specifications, and anything necessary for the construction of the work which may be called for in the drawings and omitted in the specifications, or vice versa, shall be executed and carried out as if fully called for in both.

Specifications for substructures will generally include a profile showing the probable nature of the material to be excavated, and while reasonable care will be taken in the preparation of such profile, the City will not be responsible for the correctness thereof.

Stress sheets and general plans.

4. When proposals are made on designs submitted by Contractors, such proposals shall be accompanied by complete stress sheets and general plans, and such detail drawings as may be necessary to show the dimensions of all the parts.

Stress sheets shall show separately the maximum stresses due to the different loads and the total maximum stress and sectional area required for each member. They shall also show the make-up of each member, and in addition the length and least radius of gyration of all compression members. The bending moments shears, and web and flange areas of all girders shall be stated. For reinforced concrete structures the details of the reinforcement must be clearly shown.

Size of drawings.

5. All stress sheets and detail drawings shall preferably be made on sheets of the following standard sizes:—

$8\frac{1}{2}$" x 11" (letter size)

15" x 20"

20" x 30"

30" x 40"

Approval of drawings.

6. Upon the acceptance of the tender and execution of the contract the successful Contractor shall furnish the Engineer with two complete sets of blue prints of all stress sheets, working drawings, bills of material and erection diagrams, one set of which will be approved and returned to the Contractor or returned for such correction as the Engineer may deem advisable. Drawings returned for correction must be submitted again for approval, as specified for original drawings. On receipt of the approved drawings the Contractor shall furnish the Engineer with one set of Vandyke prints of such drawings.

No work shall be commenced or materials ordered until the working drawings are approved by the Engineer in writing; if such working drawings are detained more than one week for examination the Contractor will be allowed an equivalent extension of time.

Fittings.

7. The Contractor shall be responsible for the correctness of shop drawings as to fittings and lengths, notwithstanding the approval of the Engineer.

Headroom.

8. All through bridges shall have a clear headroom of at least 14 feet over the roadway.

Clearance over railways.

9. Bridges over railway tracks must fulfil all legal requirements as regards clearance, such requirements being shown on Diagram I.

Clearance for electric railways.

10. Bridges carrying electric railway traffic, or those over electric railway tracks, shall have headroom and clearance as shown on Diagram II.

Inspection.

11. The Contractor must furnish all facilities for the inspection of materials and workmanship. The Engineer or anyone appointed by him to inspect the work shall have full access at all times to the works, shops and yards of the Contractor for the purpose of carrying out such inspection.

Maintenance of traffic over railways.

12. While any work is being carried on that will interfere with the traffic of any railway, the railway company will, if necessary, have an inspector or watchman to signal trains and to maintain traffic generally. Any orders necessary for the maintenance of traffic that may from time to time be given by such inspector or watchman shall at once be carried out by the Contractor without question, and if the Contractor shall not carry them out, or refuse to do so, the railway company may do whatever is necessary with their own men, and the cost shall be deducted from any moneys due the Contractor. The Contractor must bear the cost of all railway inspection.

Final payments.

13. On contracts where the final payments are based on unit prices, payment will be made on the net quantities as shown on the drawings except as specified below.

(a) On excavation where shoring is required, the Contractor will be allowed a width of 12 inches to allow for this shoring, but unless otherwise specified will not be allowed payment for the shoring itself.

(b) On structural steel, the Contractor will be allowed scale weight, provided this does not exceed by more than 2½% the net estimated weight as taken from the working drawings. When the scale weight exceeds the above estimated weight by more than 2½% the Contractor will be paid for such estimated weight plus two and one-half per cent. (2½%).

Payment will not be made on field rivets, the contract being considered to include such rivets.

C. H. RUST,
City Engineer.

R. E. CHADWICK,
Bridge Engineer.

October 15, 1910.

Form B-34-1000-10-10.

Mr. C. R. Young.
113 Winchester

CITY OF TORONTO.

General Specifications for Bridges.

CLASSIFICATION AND LOADING.

SECTION B.

Classification.

1. Bridges will be classified according to loading as follows:—

Class A.—Highway bridges with electric railway tracks.

Class B.—Highway bridges without electric railway tracks.

Class C.—Electric railway bridges.

Class D.—Foot bridges.

General loading.

2. All parts of the structure shall be proportioned to carry the specified dead, live, and wind loads, impact, and stresses due to change of temperature, centrifugal force and tractive force, without exceeding the unit stresses specified in Section C of these specifications.

Dead load.

3. The dead load shall be the estimated weight of the structure itself, including floor, paving and street railway tracks and ties. In no case shall the dead load be less than the actual weight of the bridge. For computing the dead load the weights of the material shall be taken from Table I. accompanying these specifications.

Live load class A.

4. The live loads for Class A bridges shall be as follows:—

(a) For the floor slab or covering a load of 4,000 pounds without impact applied midway between stringers on a strip of flooring one foot wide.

(b) For stringers a 20-ton road roller of dimensions shown on Diagram III., the load to be considered without impact and as equally distributed over a width of 10 feet. Stringers under street railway tracks shall be designed for the live loads specified below for Class C bridges, or for the roller specified above, that loading giving the greater stress being used.

(c) For the floor beams, the maximum possible concentration due to the passing of two street railway cars and the specified road roller, with an increase of 25 per cent. in the unit stresses; provided, however, that the sections be not smaller than those required for the cars alone with normal unit stresses.

(d) For the trusses or main girders, uniform loads as given in Table II. When the stress in any web-member of the trusses due to the maximum floorbeam concentration exceeds that due to the uniform load, the member shall be designed for the greater stress.

(e) For sidewalk flooring, stringers and brackets a uniform load of 100 pounds per square foot.

Live load Class B.

5. The live loads for Class B bridges shall be as follows:—

(a) For the floor slab or covering, a load of 4,000 pounds as specified for Class A.

(b) For the stringers, a 20-ton road roller as specified for Class A.

(c) For the floorbeams, a 20-ton road roller as specified for Class A, or a uniform load of 135 pounds per square foot of floor surface; that loading which produces the greater stress being used.

(d) For the trusses or main girders, a uniform load per square foot of floor surface as given in Table II.

(e) For sidewalk flooring, stringers and brackets, a uniform load of 100 pounds per square foot.

Live load Class C.

6. The live loads for Class C bridges shall be as follows:—

For all parts of the structure, the maximum loads due to a train of two 40-ton electric railway cars on each track of the dimensions shown in Diagram III., followed by a uniform load per lineal foot of single track as given in Table II.

Live load Class D.

7. The live loads for Class D bridges shall be as follows:—

For all parts of the floor system, a uniform load of 100 pounds per square foot of floor. For the trusses, a uniform load of 75 pounds per square foot of floor.

Wind loads.

8. Steel bridges of spans not greater than 200 feet shall be braced to withstand the following assumed wind loads:—

For Classes A, B and C, horizontal loads of 200 pounds per lineal foot on the top chords of through bridges or the bottom chords of deck bridges, and 500 pounds per lineal foot on the bottom chord of through bridges and the top chord of deck bridges. For Class D, one-half the above loads.

For steel bridges of over 200 feet span, and for all classes of concrete bridges, the wind load shall be assumed at 40 pounds per square foot of exposed surface on the unloaded structure, in addition to which a uniform load of 300 pounds per lineal foot, applied eight feet above the level of the floor, shall be added to the loaded structure.

Wind loads when considered.

9. Stresses in truss members or trestle posts from the assumed wind loads need not be considered except as follow:—

(a) When the wind stresses in any member exceed 25 per cent. of the maximum stresses due to the dead and live loads upon the same member. The section shall then be increased until the total stress per square inch will not exceed by more than 25 per cent. the specified unit stress.

(b) When the wind stress alone, or in combination with a possible temperature stress, can neutralize or reverse the stress in any member.

Centrifugal force.

10. To resist centrifugal force, bridges of Classes A and C, when on a curve shall have added to the lateral wind loads a force of 10 pounds per foot for each degree of curve for single track. This force shall be assumed to act at a point five feet above the top of rail.

Impact classes A. & C.

11. To counteract the effect of impact and vibration in bridges of Classes A and C, the stresses in the stringers which carry rails and in floorbeams which carry a single line of track, shall be increased by the difference between the stresses due to electric railway cars and those due to the dead load. Stresses in floorbeams which carry a double line of track shall be increased by one half this amount. Impact on any member shall be considered in designing all of its connections.

Impact classes B. & D.

12. No impact will be considered in bridges of Classes B and D.

Temperature.

13. Change of temperature to the extent of 100 degrees Fahrenheit shall be provided for, and any stresses caused by such variation of temperature shall be computed and added to the stresses due to other causes.

Tractive force.

14. Longitudinal bracing of trestle towers and similar structures for bridges of Classes A and C, shall be proportioned to resist a force of 20,000 pounds for each track, such force being applied at the rail.

C. H. RUST,
City Engineer.
January 2nd, 1910.

FORM B. 500—4—'10

CITY OF TORONTO

General Specifications for Bridges.

SECTION C.

PROPORTION OF PARTS.

Length of spans for calculation of stresses.

1. For calculating stresses the length of span for trusses and girders shall be the distance between centres of end pins or centres of bearing plates, and for rigid arches the span of the neutral axis of the arch measured where it intersects the plane of the springing of the intrados.

Length of floor beams and stringers.

2. For proportioning floor beams and stringers the lengths shall be taken as the distance centre to centre of trusses and centre of floor beams respectively.

Depth of trusses.

3. The depth of trusses shall be the distance between centres of gravity of the chords.

Length of compression members.

4. The length of compression members shall be the distance between centres of pins for pin-connected spans or between connection plates in riveted spans. In trestle posts the length shall be the distance from cap or base to centre of intermediate struts.

Rise of arches.

5. The rise of rigid arches for calculation of stresses shall be the vertical distance from the springing point of the intrados to the neutral axis at the crown.

Alternate stresses.

6. Members subject to alternate stresses of tension and compression shall be proportioned to resist each kind of stress. For determining the sectional areas both of the stresses shall, however, be considered as increased by an amount equal to eight-tenths of the least of the two stresses.

Combined stresses.

7. When any member is subjected to the action of both axial and bending stresses, as in the case of end posts of through bridges, or of chords carrying distributed floor loads, it must be proportioned so that the greatest fibre stress will not exceed the allowed limits for tension or compression on that number.

Wind stresses

8. Unit stresses may be increased 25 per cent. for loads due to wind or temperature only, or combinations of both, but the sections shall not be less than that required without these loads.

Length of compression members.

9. No compression member shall have a length exceeding forty-five times its least width, nor an unsupported length in any direction exceeding 100 times its least radius of gyration about an axis perpendicular to that direction, excepting wind bracing and lateral struts, which may have an unsupported length of 120 times the least radius of gyration.

Rivets.

10. In proportioning rivets the diameter of the rivet before driving shall be used.

Net section through rivet and pin holes.

11. In estimating the net section of riveted tension member the rivet holes shall be taken as $\frac{1}{8}$ inch larger than the undriven rivet.

Pin-connected riveted tension members shall have a net section through the pin-holes at least 25 per cent. in excess of the net section of the body.

Rolled sections.

12. Rolled sections shall be proportioned by their moments of inertia.

Concrete slabs and beams.

13. All slabs, beams and girders of monolithic reinforced concrete construction shall be considered to be partially continuous and shall have an amount of reinforcing in the upper part of the beam at the supports equal to at least one-half that in the lower part of the beam at the section of maximum positive moment.

Bending moments and reactions concrete beams.

14. For partially continuous concrete beams and slabs the maximum positive bending moment shall be taken at eight-tenths the corresponding moment as determined for simple beams, and the maximum negative moment at intermediate supports shall be taken at one-half the maximum positive moment.

Beams.

15. The reactions for partially continuous beams shall be taken at $1\frac{1}{4}$ times the reactions for simple beams at all intermediate supports. In calculating shearing stresses and proportioning reinforcing members this increase shall be taken into account.

Stress-strain curve.

16. The stress-strain curve for concrete in compression shall be assumed to be a straight line.

Concrete arches.

17. Concrete arches shall be proportioned, by the method of analysis based on the elastic theory of the arch, to carry the live loads specified in Section B for trusses. At least two conditions of live load must be assumed, the live load covering the entire arch or covering one-half the arch.

Unit stresses.

18. All parts of bridges of all classes shall be proportioned so as not to exceed the following maximum unit stresses per square inch.

MEDIUM STEEL.

Medium steel.

19.	Tension on net section	16,000
	Compression on gross section	16,000—70 l/r

Where l = unsupported length in inches.

r = least radius of gyration in inches.

20.	Bending on extreme fibres of rolled shapes and built sections	16,000
	On extreme fibres of pins	24,000
21.	Shearing on shop driven rivets	10,000
	On field driven rivets and turned bolts	8,000
	On webs of plate girders (gross section)	10,000
	On pins	12,000
22.	Bearing on shop driven rivets	20,000
	On field driven rivets and turned bolts	16,000
	On pins	24,000
	On steel rollers per lineal inch	600 d

Where "d" is the diameter in inches.

Soft steel.

23. Soft steel may be used with unit stresses ten per cent. less than those allowed for medium steel.

Eye bars.

24. Tension on eye-bars 17,000

Single angles.

25. Single angles subjected to direct tension must be connected by both legs or the section of one leg only will be considered as effective.

KIND	Tension with Grain	Bending Extreme Fibre Stress	Compression			Shearing	
			End Bearing with Grain	Bearing across Grain	Values of "C" in Column Formula	With Grain	Across Grain
White Oak	1200	1200	1000	500	1000	200	1000
Long Leaf Yellow Pine	1200	1200	900	350	900	150	1250
Short Leaf Yellow Pine	1000	1000	900	250	900	100	1000
Douglas Fir	1000	1000	900	200	900	125	1000
Norway Pine	800	800	800	200	800	100	500
Spruce and Eastern Fir	800	800	800	200	800	100	750
White Pine	700	900	700	150	700	75	500
Hemlock	600	600	700	150	700	100	600

$$\text{For columns } P = C \frac{700 + 15\,l/d}{700 + 15\,l/d + l^2/d^2}$$

When P = unit stress in pounds per square inch.
C = constant given in the above table.
l = unsupported length in inches.
d = least side in inches.

27. The unit stress on columns less than 15 diameters in length shall not exceed the values given for the constant "C."

MASONRY.

Masonry.

28. Bearing under bed plates on best ashlar masonry and on concrete.

Sandstone	300	pounds per square inch
Limestone	300	" " " "
Stone or gravel concrete, 1:3:6	400	" " " "
Stone or gravel concrete, 1:2:4	500	" " " "
Granite	500	" " " "

29. Bearing in piers for best ashlar masonry and for concrete.

Sandstone	300	pounds per square inch
Limestone	300	" " " "
Stone or gravel concrete, 1:2:6	300	" " " "
Stone or gravel concrete, 1:2:4	400	" " " "
Granite	400	" " " "

REINFORCED CONCRETE—1:2:4 MIXTURE.

Allow 75% of these stresses for 1:2½:5 Concrete.

Compression.

Reinforced concrete.

30. In columns whose length does not exceed 15 times their least width.

Stone or gravel concrete	400	pounds per square inch
Slag concrete	300	" " " "

For hooped columns these stresses may be increased 50 per cent.

On extreme fibres of beams and slabs for bending.

Stone or gravel concrete	700	pounds per square inch
Slag concrete	400	" " " "

Shearing.

Shearing.

31.

Stone or gravel concrete	60	pounds per square inch
Slag concrete	40	" " " "

Bond Between Steel and Concrete.

32.

Stone or gravel concrete	50	pounds per square inch
Slag concrete	40	" " " "

Ratio of Moduli of Elasticity of Steel to Concrete.

33.

Stone or gravel concrete	12
Slag concrete	15

Tension.

34.

Soft steel	14,000	pounds per square inch
Medium steel	16,000	" " " "

High steel—one-half the elastic limit, but not more than 20,000 pounds per square inch.

FOUNDATIONS.

Bearing power of soils.

35. The bearing power of soils under foundations shall, if possible, be based on actual test. Where this is impracticable the following shall be used:—

Gravel and coarse sand, well cemented	8	tons per square foot
Dry hard clay	4	" " " "
Sand, compact and well cemented	4	" " " "
Moderately dry clay or clean dry sand	2	" " " "
Wet clay	1	ton " " "
Quicksand or alluvial soils	0 to ½	" " " "

Piles.

36. The safe bearing power of wooden piles shall be that given by the following formula:—

$$P = \frac{2\,w\,h}{s + 1}$$

When P = safe load in pounds.
w = weight of hammer in pounds.
h = fall of hammer in feet.
s = penetration of last blow in inches.

C. H. RUST,
City Engineer.

R. E. CHADWICK,
Bridge Engineer.

October 15th, 1910.

Form B-35-1000-10-10.

CITY OF TORONTO

General Specifications for Bridges.

SECTIONS E.

REINFORCED CONCRETE BRIDGES—DETAILS OF DESIGN.

Plans.

1. All parts of the structure shall be built in accordance with approved plans, showing details of reinforcement.

Beams and slabs, assumptions for design.

2. Reinforced concrete beams and slabs shall be designed on the assumption that a plane before bending shall remain a plane after bending, and that the stress-strain curve shall be a straight line. No allowance will be made for concrete in tension.

Slabs reinforced in both directions.

3. The bending moments for square and rectangular slabs reinforced in both directions shall be assumed to be one-half that for slabs reinforced in one direction only.

Beams carrying slabs reinforced in both directions.

4. Beams carrying slabs reinforced in both directions shall have their moments increased 30 per cent. owing to the concentration of the slab reaction near the centre of the beams.

"T" beams.

5. In monolithic beam and slab construction a portion of the slab may be considered as effective flange area for resisting compression in the beams and girders, but the allowable unit fibre stress on such area shall be 25 per cent. less than that given in Section C. of these specifications for concrete in compression. The width of slab considered as flange area shall not be greater than 12 times the thickness of the slab, nor 6 times the thickness of the stem of the beam, nor one-half the span of the slab.

Casting "T" beams.

6. "T" beams must be cast so as to leave no plane of cleavage at the junction of the stem of the beam and the slab. Where this is impossible enough steel stirrups must be provided to take the whole horizontal shear without any reliance on the concrete.

Continuous "T" beams.

7. When "T" beams are considered as partially continuous, the compression on the lower side of the beam at the point of maximum negative moment must be computed, and if it exceeds the maximum allowable unit stress on concrete, sufficient steel must be provided to take the excess stress.

Stirrups.

8. In all beams and slabs when the horizontal shear per square inch exceeds the allowable shearing stress on concrete, steel stirrups shall be provided to take the excess shear and any diagonal tension that may exist. Two-thirds of the main tension rods may be bent up at the ends to provide material for resisting horizontal shear.

Vertical shear.

9. Enough concrete must be provided to take the vertical shear at any point in a beam or girder without any reliance on the steel reinforcing unless the steel be of such a character that it will take the shear itself without reliance on the surrounding concrete.

Diameter of columns.

10. The unsupported length of a column shall not exceed fifteen times its least lateral dimension.

Bending in columns.

11. Columns shall be designed to resist, in addition to the vertical loads, any bending that may be produced by considering the full live load acting in the panels to one side of the column with no live load on the panels to the other side. Bending due to any eccentricity of the vertical loads shall also be considered.

When columns are subjected to both direct compression and flexure, the extreme fibre stress resulting from the combined actions shall not exceed by more than 25 per cent. the allowable unit stresses specified in Section "C" of these specifications for compression in columns. In no case, however, shall the section be less than that required for the direct compression alone.

Longitudinal reinforcement in columns.

12. All columns shall have longitudinal reinforcement so arranged as to make the column capable of resisting flexure and in no case shall the combined area of steel be less than one per cent. of the area of concrete used in proportioning the column. Such longitudinal rods shall be stayed against buckling at points whose distance apart does not exceed twenty-four times the least lateral dimensions of the rod.

Heoped columns.

13. Hooped columns shall have an area of hooping not less than one per cent. of the vertical section, preferably in the form of a spiral having a pitch not greater than one-quarter of its diameter. At least one per cent. of longitudinal reinforcement shall be provided.

The allowable unit stress on hooped columns, considering only that portion enclosed within the hooping as effective, shall be 50 per cent. in excess of that specified for ordinary reinforced concrete columns.

Fill over arches and culverts.

14. For proportioning arches 150 pounds per cubic foot shall be taken as the weight of concrete and 125 pounds per cubic foot as the weight of earth fill.

The pressure of earth fills over arches and culverts shall be assumed to be equal to the weight of material included between two planes at the ends of the span, making an angle with the vertical equal to one-half the angle of repose of the material with the vertical, but when these planes intersect above the top of the fill the total weight of material between vertical planes shall be considered as carried.

Arch rings.

15. Arch rings which are not reinforced shall be of sufficient thickness so that the line of pressure will not pass outside the middle third of the ring. The area of steel at the crown of reinforced arch rings shall in no case be less than one-half of one per cent. of the area of the concrete, and at all points in the ring there shall be sufficient steel to take the bending moment alone without reliance on the surrounding concrete. Arch rings shall have transverse reinforcement sufficient to resist the bending moment due to the thrust of the filling on the spandrel wall.

Temperature.

16. A range of temperature of $\pm$ 50° Fahrenheit shall be assumed for all arch rings.

Pressure of back filling on retaining walls.

17. The lateral pressure on retaining walls due to back filling shall be assumed to act at a point one-third of the height of the wall above grade, and to be equal in amount to the weight of the back filling material included between the vertical and a plane bisecting the angle between the plane of repose of the back-filling material and the vertical.

Superimposed load on retaining wall.

18. When any superimposed load is carried between the bisecting plane referred to in the last clause and the back of the wall, it shall be added to the load due to back-filling.

Footings.

19. Reinforced concrete footings shall be deep enough to transmit the vertical column loads by shear on the concrete alone without reliance on the reinforcing rods.

Length of rods.

20. Reinforcing rods shall be of sufficient length to develop the full stress in the rod without exceeding the allowable unit stress for bond between concrete and steel.

Deformed rods.

21. Twisted squares or other approved deformed rods will be preferred for all work under water and for all parts of bridges of Classes A and C. The allowable union stresses for bond between concrete and steel may be increased to 50 per cent. when such rods are used.

Protection to steel.

22. All steel used for reinforcing except that below grade or below water level shall be protected by a covering of concrete of the following thickness :—

For slabs 3 inches or less in thickness.....	$\frac{1}{2}$ inch.
For slabs over 3 inches in thickness.....	1 inch.
For beams, columns, walls, arches, etc.....	2 inches.

Steel below grade or below water level shall be protected by a covering of at least 4 inches for all classes of work.

Expansion joints.

23. Unless special reinforcement is provided for temperature stresses, expansion joints shall be provided in all walls and footings at intervals not exceeding 50 feet, and in spandrel walls of arches at the crown and at the haunches.

All expansion joints shall be provided with proper keys to prevent lateral displacement.

Water-proofing.

24. Unless otherwise specified all arch rings and slabs carrying earth fills, and the backs of all retaining walls and spandrel walls shall be properly waterproofed by at least four layers of approved felt laid in hot asphalt.

Where waterproofing is carried over an expansion joint, it must be so arranged as to allow free expansion and contraction without damage to the waterproofing.

Patented systems.

25. Structures designed and constructed in accordance with patented or other systems of reinforcement which are not subject to rigid stress analysis shall have a factor of safety of four after thirty days based on actual test.

Tests.

26. Parts of structures designed and built in accordance with plans submitted by Contractors may be tested at the option of the Engineer, and shall be capable of carrying four times the load for which they were designed without failure.

Should any parts be tested to destruction and prove satisfactory they shall be paid for at cost less the scrap value to the Contractor. If they do not stand the specified tests they shall be considered as rejected at the cost of the Contractor.

C. H. RUST,
City Engineer.

March 1st, 1912.

4—80—2—12—500.

CITY OF TORONTO

General Specifications for Bridges.

SECTION F.

PLAIN AND REINFORCED CONCRETE—DETAILS OF CONSTRUCTION.

Forms

1. Forms and centres for moulded concrete shall be constructed of sufficient strength and rigidity to prevent any motion while the concrete is being placed. They shall be strong enough to carry in addition to the dead load any superimposed load that may be placed on the work during construction.

Proportioning forms and centres.

2. In proportioning forms and centres concrete will be treated as a liquid of its full weight for vertical loads, and of one-half of its weight for horizontal pressures.

The unit stresses for forms and centres shall not exceed by more than fifty per cent. the stresses specified in Section C of these specifications for timber.

Centres for arches.

3. In constructing centres for arches of more than 30 ft. span, all main members shall be securely bolted together, as no reliance will be placed on spiking.

Arch centres shall be so constructed as to allow for a settlement of one-half inch for each twenty-five feet vertical height.

Material for forms.

4. Forms for all surfaces that will be exposed in the finished work shall be made of tongued and grooved or matched sheeting dressed on the inside to a smooth surface. They shall be built so as to be as nearly water-tight as possible.

Forms for other work may be made of undressed lumber, but the joints must be reasonably tight so as to prevent any loss of cement through leakage. All work to a depth of eighteen inches below the finished grade shall be treated as "exposed work."

Oil or soap.

5. In order to prevent the cement from sticking, all forms for exposed work shall be oiled or soaped on the side next the finished work. The oil to be used shall be thick enough to act as a filler, that quality being known as "sludge" being recommended. If soap is used, it shall be mixed with enough water to make a thin jelly. When forms are used more than once they shall be carefully cleaned of all cement, and shall then be given another coat of oil or soap.

Debris in forms.

6. Care must be taken to remove all sawdust, shavings and other debris from forms just before placing the concrete, and if necessary a steam jet or other effective means shall be provided for this purpose.

All forms for columns and deep girders shall have an opening left at the bottom for the removal of rubbish.

Workmanship.

7. Forms shall be constructed by experienced and capable workmen only. They shall be true to line and grade and of first-class workmanship throughout.

Inspection of forms.

8. Forms shall be subject to rigid inspection and must be satisfactory to the Engineer in every respect before any concrete will be allowed to be placed.

Removal of forms.

9. In general forms shall not be removed, in less than 14 days in Summer, or 28 days in Winter, except in the case of vertical surfaces which do not carry load.

In beam and girder construction the forms shall be removed from the columns before removing the shores from the beams and girders, so that the column concrete may be effectively inspected. The forms for large beams and girders shall be constructed so that the sides may be removed without disturbing the shores.

Removal of centres.

10. Centres shall not be struck from under arches in less than 28 days, except in the case of culverts under 25 feet span. In all cases care must be taken to remove the centres gradually without shock to the concrete.

Notice of removal of forms.

11. No forms or centres, except for minor parts, shall be removed without notice to the Engineer. Such notice shall not, however, relieve the contractor of responsibility for the safety of the structure, or of liability in case of accident.

No sharp corners.

12. Whenever possible the edges of beams, girders, and columns shall be chamfered and the sides of beams and girders splayed in order that the forms may be more readily removed.

Projecting wires and bolts.

13. All projecting wires and bolts or other devices used for holding forms, and that pass through the concrete, shall be cut off at least one inch beneath the finished surface and the ends covered with cement mortar of the same mix as that used in the body of the work.

Reinforcing rods.

14. All reinforcing rods shall be placed in the positions shown on the drawings, and must be securely wired or otherwise fastened, so as not to be disturbed while placing or tamping the concrete. If necessary, rods shall be wired at each intersection.

Proportioning concrete.

15. Unless otherwise specified, all concrete shall be mixed in the following proportions by volume:—

(a) For arches, slabs, girders, beams, floors, walls subject to transverse stress, columns, etc., 1 part Portland cement, 2 parts sand, and 4 parts broken stone or gravel, all of which will pass in any direction through a 1½ inch ring and be held on a ¼ inch ring.

(b) For spandrel and retaining walls less than 24 inches in thickness, 1 part Portland cement, 2½ parts sand, and 5 parts broken stone or gravel, all of which will pass in any direction through a 1½ inch ring and be held on a ¼ inch ring.

(c) For spandrel and retaining walls, piers and abutments, not less than 24 inches, nor greater than 36 inches in thickness, 1 part Portland cement, 3 parts sand, and 6 parts broken stone or gravel, all of which will pass in any direction through a 2 inch ring.

(d) For spandrel and retaining walls, piers and abutments, greater than 36 inches in thickness, and all foundations, 1 part Portland cement, 3½ parts sand, 7 parts broken stone or gravel, all of which will pass in any direction through a 3 inch ring.

Changes.

16. It is understood that all proportions for concrete are subject to such changes as may from time to time be found necessary to obtain a properly balanced mixture without voids. Should such adjustment of proportions require a larger volume of cement to aggregate than that specified, the contractor shall be allowed the actual cost, delivered at the mixer, of such additional cement. In case a less amount of cement is required, a deduction of actual cost, less 10 per cent., will be made.

One-man stones.

17. On heavy foundations or other work requiring large masses of concrete, 25 per cent. of one-man stones may be impedded in the concrete. Such stones shall be sound and perfectly clean, and shall be thoroughly wet before placing. They shall be laid with their largest face down, and shall not be placed nearer than one foot from the surface of the work or from each other.

Measuring materials.

18. All materials for concrete shall be accurately measured so as to have the exact proportions. This will preferably be done in boxes, specially constructed for the purpose, but the use of iron barrows may, with the Engineer's consent, be used for measuring stone and sand.

All concrete materials shall be measured loose.

Machine mixing.

19. When the amount of concrete in the work exceeds 500 cubic yards, it shall be mixed in approved mixing machines. The materials for each batch shall be carefully measured and mixed dry. Clean water shall then be added and the mixing continued until the mass is uniform throughout.

Continuous mixing machines will not be allowed.

Hand mixing.

20. When the amount of concrete is less than 500 cubic yards, the mixing may be done by hand. It shall be done on a tight, smooth platform not less than 14 feet by 12 feet, with a raised rim around the edge at least three inches in height, to prevent any loss of mortar. The sand shall first be evenly spread on this platform, and the proper proportion of cement shall then be spread over the sand. These ingredients shall then be thoroughly mixed with hoes or shovels, then heaped up in a pile in the centre of the platform, and then spread out evenly over the surface while in a dry state. Clean water must then be applied and the mortar thoroughly mixed wet. The stone or gravel shall then be spread evenly over the mortar, and the whole mass thoroughly mixed with hoes or shovels, being turned over at least three times, not counting the shovelling off the board. Not more than ¾ of a cubic yard shall be mixed in any one batch.

Proportion of water.

21. For concrete that is reinforced and for all surfaces that will be exposed in the finished work, enough water shall be used to make what is termed a "wet mixture."

For foundations and other heavy work the mixture shall be such that water will flush to the top only after heavy ramming.

Depositing concrete.

22. All concrete shall be deposited in the work as soon as possible after mixing, and in no case shall concrete which has attained its initial "set" be used.

Concrete shall be deposited in even layers not greater than eight inches in thickness, and thoroughly tamped so as to leave no voids, the tamping being continued until water flushes to the surface. When a "wet" mixture is used, the tamping may be omitted, but the mass shall be thoroughly worked with a flat iron bar, special care being taken to surround all reinforcing rods and to remove all air bubbles from the surface next the forms.

Concrete deposited in water.

23. When it is necessary to deposit concrete under water, the structure shall be encased with a cofferdam, or other means shall be taken to insure quiet water. The concrete shall be deposited from a bucket provided with a bottom dump, and care shall be taken to keep the surface of the concrete as nearly horizontal as possible.

The proportion of cement in concrete deposited under water shall be 25 per cent. in excess of that required for similar work deposited in the ordinary way. No extra compensation will be allowed the contractor for such extra cement.

Joints.

24. The mixing and placing of concrete shall be as far as possible a continuous operation, but when it is necessary to make a joint, it shall be at right angles to the line of stress.

Joints in monolithic beam and slab construction shall be made only over the beams. They shall be made by means of a stop board placed in a vertical position and having a key on the side next the concrete first placed.

Joints in arch rings shall be made by means of a stop board placed radially to the curve of the arch and having a key as specified for beam and slab construction.

Expansion joints.

25. Expansion joints shall be made by means of stop joints containing proper keys. Unless otherwise specified, the bond shall be broken by a heavy coat of asphalt applied hot to the surface of the concrete first placed.

Bond.

26. When it is necessary to bond new concrete, to concrete partially or wholly set, the surface of the old concrete shall be swept clean and thoroughly roughened by picking. A coating of 1 to 1 cement mortar shall then be applied before continuing the work.

In reinforced concrete construction the Engineer may require the joints to be cleaned by acid. Care shall be taken to remove all traces of the acid by thoroughly washing before applying the mortar for the new work.

Protecting concrete.

27. Concrete shall be kept wet for one week after depositing, and in hot weather must in addition be kept covered from exposure to the sun during this time, or must be constantly sprinkled during the day by a workman especially detailed for this work.

Protecting material.

28. All stone, sand and gravel for use in the concrete, shall be deposited on clean boards, and protected from dirt.

29. No concrete shall be laid in freezing weather, except by the special permission of the Engineer, and unless arrangements are made for heating all the materials and maintaining a temperature above the freezing point until the concrete has set.

Surface finish.

30. After the removal of the forms all exposed surfaces shall be carefully examined and all cavities filled with dry mortar of the same proportions as that used in the original work. All projections shall be carefully ground down or chipped off and the work left smooth and true to line.

Before mortar is applied to any surface, it shall be thoroughly cleaned, and all "dead" cement chipped off or otherwise removed. It shall then be saturated with water, and the mortar applied to the wet surface.

Rubbed finish.

31. If a "rubbed finish" is specified, as soon as the forms have been removed, and all cavities filled, a wash of one part of cement to two parts of fine sand shall be applied and the whole gone over with a piece of sandstone and the surface ground down sufficiently to remove all irregularities.

Washed finish.

32. If a "washed finish" is specified, the forms shall be removed about ten hours after the concrete has been deposited, and the surface scrubbed with clean water or a solution of muriatic

acid, so ase to remove the surface cement and expose the stone. If necessary wire brushes shall be used for this purpose.

Care shall be taken to thoroughly wash any surface to which acid has been applied, so as to remove all traces of same.

Tooled surfaces.

33. If bush hammered or other tooled surfaces be specified, the work shall be done with such tools and in such manner as is usual for similarly dressed surfaces of stone.

C. H RUST,
City Engineer.

B-5 61-500. May 1st, 1911.

CITY OF TORONTO.

General Specifications for Bridges.

SECTION G.

STEEL SUPERSTRUCTURE.

Details of Design and Construction.

General. 1. All parts of the superstructure shall be built in accordance with approved plans, and workmanship shall be equal to the best practice in modern bridge shops.

Designs of truss members. 2. Members of trusses, trestle bents, etc., shall be so designed as to be as nearly symmetrical about the centre of gravity of the section as practicable. In compression chords and end posts of trusses the material shall be concentrated as far as possible in the vertical webs and angles. Upper and lower chords shall be of box section.

Camber. 3. Bridges shall be cambered by giving the panels of the top chord an excess of length in the proportion of about 1/8 inch to every ten feet.

Intersecting members. 4. The neutral axes of all intersecting members of trusses shall meet at a point. Where this is impossible the members shall be proportioned to take any bending that may result from the eccentricity of the connection.

Open sections. 5. Preference shall be had for such details as shall be most accessible for inspection, cleaning and painting; no closed sections will be allowed.

Diaphrams 6. At all points where floor beams, portals or other bracing connects with posts or chords, diaphragms must be inserted to distribute the load over the whole section.

Water pockets. 7. Pockets or depressions that will hold water shall be avoided. Where this is impossible they shall be provided with drain holes or be filled with approved waterproof material.

Strength of details. 8. All connections and details shall be of such strength that failure would take place in the body of any member rather than in any of its connections.

Minimum sections. 9. No plates or angles, unless used as fillers, shall be less than 3/8 inch thickness, except for lateral bracing, lattice bars, etc., which may have a minimum thickness of 5/16 inch; con-

nection angles for stringers and floor beams shall not be less than 7/16 inch thick. Angles less than 3 inches by 2½ inches and channels or beams less than 6 inches deep, shall not be used except with the expressed permission of the Engineer.

Rivets.

10. Rivets shall preferably be ⅞ inch diameter, except in minor details. When driven they must completely fill the holes, and heads must be neatly formed and be of uniform size and concentric with the body of the rivet. Caulking or re-cupping will not be allowed. Drift pins may be used only for bringing together or holding the several pieces forming a connection.

Bolts.

11. Bolts shall be used in place of rivets only with the expressed permission of the Engineer. When so used the holes must be reamed and the bolts turned to a driving fit and provided with washers ¼ inch thick.

All bolts must have hexagonal heads and nuts and United States standard threads.

Pitch of rivets.

12. The distance between centres of rivet holes shall not be less than three diameters of the rivet, nor more than 6 inches in the line of stress for ⅞ inch rivets and 5 inches for ¾ inch rivets. At the ends of compression members the pitch of rivets in the line of stress shall not exceed four diameters of the rivet for a distance equal to twice the depth of the member. The pitch of rivets perpendicular to the line of stress in compression members shall not exceed forty times the thickness of the thinnest outside plate.

Edge distance of rivets.

13. The minimum distance from the centre of a rivet to a rolled or planed edge shall not be less than 1¼ inches for ⅞ inch rivets, or 1⅛ inches for ¾ inch rivets, and to a sheared edge 1½ inches and 1¼ inches respectively. The maximum distance from any edge shall be eight times the thickness of the plate, but not more than 6 inches.

Grip of rivets.

14. The total thickness of metal gripped shall not exceed five times the diameter of the rivet.

Punched holes.

15. Punched holes shall be clean cut and without torn or ragged edges. Holes will generally be punched 1/16 inch larger than the rivet, and the diameter of the die shall not exceed that of the punch by more than 1/16 inch.

Accuracy of spacing.

16. Rivet holes must be so accurately spaced that when the several parts forming one member are assembled together the rivets may be generally entered hot without driving. Occasional variations must be corrected by reaming.

Reamed holes. Classes A. B. and C.

17. For bridges of classes A. B. and C.—All rivet holes, except in lateral and sway bracing, and in buckled plate or other solid flooring shall be punched ⅛ inch smaller than the rivet and accurately reamed to an iron template reamed true while the parts are temporarily assembled.

Reamed holes. Class D.

18. For bridges of class D.—Holes for field connections, except lateral and sway bracing, shall be reamed as specified in clause 17 above.

Amended section G. June 30. 1910

Compression members.

19. Compression members shall be milled to exact length. They shall preferably be made without splices, but when this is impracticable the joints shall be placed as close to panel points as possible, and either be faced to exact bearing or be fully spliced. In all cases the abutting ends must be dressed straight and true so as to leave no open joints.

Lattice bars and tie-plates.

20. The open sides of compression members shall be properly stayed by lattice bars with tie plates at the ends and at intermediate points where the lacing is not continuous. Thickness of lattice bars shall not be less than 1/40th of the distance centre to centre of rivets for single lacing, or 1/60th for double lacing, and their width shall not be less than 2 inches for members 9 inches and less in width, nor 2¼ inches for members from 9 to 12 inches in width, nor 2½ inches for members from 12 to 15 inches in width. The length of tie plates shall not be less than their width, and the thickness shall be at least 1/40th of the distance centre to centre of rivets.

Angle of lattice bars.

Lattice bars shall be inclined to the axis of the member at an angle not less than 60 degrees for single lacing or 45 degrees for double lacing.

Forked ends.

22. Forked ends on compression members shall have a sufficient number of pin plates to make the sectional area of the jaws at any point between the inside edge of the pin and 6 inches beyond the edge of the tie plate, twice that of the member.

Pins.

23. Pins must be accurately turned to gauge and have full bearing on all parts connected to them. They shall fit the pin holes within 1/50 of an inch for pins less than 4 inches diameter, or within 1/32 of an inch for larger pins, and shall be provided with pilot nuts for driving. The several members attached to the pin shall be so packed as to produce the least bending moment, and all vacant spaces must be filled with wrought iron or steel rings. The diameter of the pin shall not be less than 4/5 of the width of the largest eye bar attached to it.

Pin holes.

24. Pin holes must be bored true to gauge and at right angles to the axis of the member. The boring shall be done after the member is riveted up, and must be correct within 1/32 inch.

Pin plates.

25. When necessary, pin holes must be reinforced with plates, at least one of which must be the full width of the member and extend 6 inches beyond the tie plate.

Eye-bars, tension members.

26. The heads of eye-bars shall be so proportioned and made that the bars if tested to destruction would break in the body rather than in the head or neck. Heads shall be made by forging, upsetting or rolling, and not by welding.

Before boring eye-bars must be straight and free from twists or other defects, and be properly annealed.

Boring eye bars.

27. Eye-bars which are to be placed side by side in the structure must be bored at the same temperature, and with such accuracy that when placed together the pins will pass through both ends at the same time without driving.

Shoes.

48. Shoes shall be so constructed as to distribute the load uniformly over the masonry, and those for spans of 80 feet and over shall be hinged at both ends.

Expansion.

49. Expansion must be provided for in all structures at the rate of $\frac{1}{8}$ inch in every 10 feet.

Expansion bearings.

50. Spans less than 80 feet shall be provided with planed friction plates at the expansion end, and spans of 80 feet or over with turned rollers not less than $2\frac{7}{8}$ inch diameter. Rollers shall be coupled together with side bars, and shall be boxed in so as to be protected from dirt. Such boxing must be so arranged as to be readily removed for cleaning and inspection.

All expansion bearings shall be secured against lifting and against transverse movement.

Bed plates.

51. Bed plates shall have a minimum thickness of $\frac{7}{8}$ inches and shall be securely bolted to the masonry. Where two spans rest on the same pier a plate not less than $\frac{1}{2}$ inch thick shall extend under both shoes.

Sheet lead.

A sheet of lead $\frac{1}{8}$ inch thick shall be put under all bed plates resting on masonry.

Anchor bolts.

52. Anchor bolts shall be at least 1 inch in diameter and extend at least 12 inches into the masonry. For trestle towers or other structures anchor bolts shall be proportioned to take any uplift that might exist, and they shall be set so as to engage a mass of masonry, the weight of which is at least one and one-half times the calculated uplift.

Painting.

53. All steel must be thoroughly cleaned before being assembled, and all loose scale and rust removed with steel scrapers and brushes. Surfaces coming in contact will then be given one coat, and parts inaccessible after assembling or erecting two coats, of such paint as the Engineer may direct. After being riveted up the whole shall receive one coat of paint worked well into the joints to the satisfaction of the Engineer.

All metal must be perfectly dry and free from frost before being painted, and kept so until the paint has dried.

Machined surfaces shall be coated with white lead and tallow before being shipped.

Name plate.

54. The Contractor is to affix, in some permanent position, a neat, well-designed name-plate, giving the name of manufacturer and the date of erection; the design of each name-plate to be approved by the Engineer.

C. H. RUST,
City Engineer.
May 1st, 1909.

CITY OF TORONTO

General Specifications for Bridges.

SECTION H.

ERECTION OF STEEL SUPERSTRUCTURE.

Work to be done.

1. Unless otherwise specified, erection is to include the following:—

Unloading the material at the site of the work.

Supply of all labor, tools, bolts, plant, equipment, and other material necessary for the completion of the work.

Supply and erection of all false work and piling required for erection of the steel and removal of same on completion of the work.

Removal of all old iron, steel, timber, and other material, and piling same where directed.

Labor, materials and tools required for painting, as specified below.

Traffic

2. The contractor shall so conduct his operations as not to impede or obstruct traffic on any railway, or to close any thoroughfare.

Accidents.

3. The contractor shall assume all risks of accidents to men or materials prior to the acceptance of the finished structure by the City.

Handling material.

4. Material must be handled with the greatest care to avoid injury. Small bends or twists received by members during transportation or erection must be corrected before the members are put in place. All material that, in the opinion of the Engineer, has been seriously damaged during transportation or erection, will be rejected.

Riveting.

5. Field driven rivets must comply with all the requirements specified in Section G of these specifications for shop rivets. They must be evenly heated throughout and driven at an orange heat. Burnt rivets will not be accepted.

Cutting rivets.

6. All defective or loose rivets must be immediately cut out when marked by the Inspector. In cutting rivets care must be taken not to damage the adjacent rivets or any of the metal of the member.

Painting.

7. After erection metal where the paint has been rubbed off, and the heads of field rivets must be cleaned of all rust and given one coat of paint. When this is dry the whole structure shall be given two coats of such paint as may be specified. The paint must be well worked into all corners and effectively seal up all joints between the different parts. The two coats of paint shall be of a different color if so directed. No painting shall be done in wet or freezing weather.

C. H. RUST,

City Engineer.

B-7-59-500

May 1st, 1911.

CITY OF TORONTO

General Specifications for Bridges.

SECTION J.

STEEL AND IRON.

Steel.

1. Steel shall be made by the open hearth process only. Four grades may be used—high steel, medium steel, rivet steel, and steel castings.

Medium steel.

2. All parts of the superstructure of steel bridges except rivets, bolts and such details as cannot be made other than by casting, shall be of medium steel.

Reinforcing rods.

3. Reinforcing rods for reinforced concrete structures shall be of medium steel or high steel.

Rivet steel.

4. Rivets and bolts shall be made of rivet steel.

Castings.

5. All important castings shall be of steel. Cast iron may be used only with the expressed permission of the Engineer.

Finished material.

6. Finished material shall be free from piping, checks, cracks, flaws, blisters, or other imperfections, and shall have a smooth finish and be true to section.

Temperature of working.

7. No work shall be put upon any steel at or near the blue temperature or between that of boiling water and of ignition of hard wood sawdust.

Annealing.

8. All eye bars, steel castings, and other steel that may have been partially heated shall be thoroughly annealed.

Welds.

9. Welds in steel will not be allowed.

Chemical and physical properties.

10. The chemical and physical properties of steel shall be as follows: —

Property	High Steel	Medium Steel	Rivet Steel	Steel Castings
Phosphorous max. Acid ...	0.08 %	0.08 %	0.04 %	0.08 %
" " Basic ..	0.04 %	0.04 %	0 04 %	0.04 %
Sulphur, max	0.05 %	0.05 %	0 05 %	0.05 %
Ultimate Tensile Strength, min	80,000 pds. per sq. in.	55,000 pds. per sq. in.	48,000 pds. per sq in.	65,000 pds. per sq. in.
Ultimate Tensile Strength, max.....	100,000 " "	65 000 " "	58,000 " "	.....
Elastic Limit, min.....	50,000 " "	½ ult. strength	½ ult. strength	½ ult. strength
*Elongation min. per cent. in inches.	1,200,000 ult. strength	1,400,000 ult. strength	1,400,000 ult. strength	1,400,000 ult. strength

* 5 % for cold twisted square bars.

Modifications in elongation for thin and thick material.

11. For material less than 5/16 inch and more than ¾ inch in thickness, the following modifications shall be made in the requirements for elongation: —

(a) For each increase of 1/8 inch in thickness above ¾ inch, a deduction of 1 per cent shall be made from the specified elongation, except that the minimum elongation shall be 20 per cent. for eye-bar material and 18 per cent. for other structural material.

(b) For each decrease of 1/16 inch in thickness below 5/16 inch, a deduction of 2½ per cent. shall be made from the specified elongation.

(c) In rounds of ⅝ inch or less in diameter the elongation shall be measured in a length equal to eight times the diameter of section tested.

(d) For pins made from any of the before mentioned grades of steel the required elongation shall be 5 per cent. less than that specified for each grade, as determined on a test piece, the centre of which shall be one inch from the surface of the bar.

Bending.

12. Steel less than 1 inch thick must bend cold, or after being heated to a red heat and quenched in water at 75° Fahrenheit, as follows, without sign of fracture:—

High Steel—180° to a curve whose inner diameter equals three times the thickness of the piece tested.

Medium Steel—180° to a curve whose inner diameter equals the thickness of the piece tested.

Rivet Steel—180° flat.

Method of bending.

13. Bending tests shall be made by pressure rather than by hammering.

Specimens, plates and shapes.

14. Specimens from plates and shapes for tensile and bending tests shall be cut from the finished product with both faces rolled and both edges milled. They shall have a width of 1½ inches.

Bars.

15. Specimens for tensile tests from rolled or forged bars used for rollers or pins shall be turned to a diameter of one-half inch; specimens for bending tests shall be 1 inch by ½ inch in section.

Rods

16. Rivet stock and rods up to 1 inch in diameter shall be tested as rolled.

Steel castings.

17. Specimens for tensile and bending tests of steel castings shall be cut after the material has been annealed. They shall be the same size as specified in Section 15 for bars.

Angles.

18. Angles ¾ inch or less in thickness shall open flat cold without sign of fracture.

Fracture.

19. All material tested to destruction shall show a uniform silky fracture.

Number of tests.

20. At least one tensile and one bending test shall be made for each melt or casting.

Annealing

21. Material which is to be used without annealing or further treatment is to be tested in the condition in which it comes from the rolls. When material is to be annealed or otherwise treated before use, the specimen representing such material is to be similarly treated before testing.

Chemical analysis.

22. Chemical analyses shall be made by the manufacturers from test ingots taken at the pouring of each melt, and a correct copy of such analyses shall be furnished to the Inspector free of charge.

If required by the Engineer, check analyses shall be made from the finished material, in which case 25 per cent. above the allowed limits for sulphur and phosphorous will be allowed.

Cost of inspection.

23. The Contractor shall furnish free of cost the use of a testing machine capable of testing the specimens at all mills where the steel may be manufactured. Mill inspection shall be done at the expense of the Contractor by an Inspector acceptable to the Engineer. The Contractor shall also supply free of cost all specimens required for testing.

Full sized tests.

24. Full-sized parts of the structure may be tested at the option of the Engineer, and if tested to destruction, such material will be paid for at cost less its scrap value to the Contractor, if it proves satisfactory. If it does not stand the specified tests, it will be considered rejected material, and be solely at the cost of the Contractor.

Reports of tests and analysis shall be sent weekly to the Engineer.

Stamping.

25. All finished material shall have stamped or rolled upon it the name of the manufacturer and the number of the melt. Small pieces may be bundled with the above information stamped on a metal tag.

Defective material.

26. Material which fails to pass the specified tests will be rejected. Material which is accepted at the mills and afterwards develops weak spots, brittleness, cracks or other imperfections, will be rejected at the shop, and shall be replaced by the Contractor free of cost.

Access to mills.

27. Mill Inspectors shall have full access at all times to all parts of the mills where the material is being manufactured.

Cast iron.

28. All castings must be of tough, gray iron, free from cold shuts or injurious blow-holes, true to form and thickness, and of a workmanlike finish. Sample pieces, 1 inch square, cast from the same heat of metal in sand moulds, shall be capable of sustaining, on a clear span of 12 inches, a central load of 2,400 pounds when tested in the rough bar. A blow from a hammer shall produce an indentation on a rectangular edge of the casting without flaking the material.

Ornamental cast iron work.

29. All ornamental cast-iron work, such as pilasters, handrail standards, lamp pillars and any other work of similar character, shall be the best of its kind. It shall be clean and smooth, sharp on all the edges, and with every embellishment well and clearly defined, without rough places, cold shut or any imperfections whatever, and shall be secured in the most workmanlike and finished manner.

C. H. RUST,

City Engineer.

July 2nd, 1910.

Form B. 31—1000—7—10.

CITY OF TORONTO

General Specifications for Bridges.

SECTION K.

CEMENT, SAND, GRAVEL, AND BROKEN STONE.

Cement.

1. Cement shall be delivered in bags or barrels, the bags to be of fine and strong quality, so as not to permit loss of weigh of cement by sifting. The barrels to be well lined and air-tight. Each barrel and its contents to weigh 375 lbs., of which 350 lbs. shall be cement. If in bags, 350 lbs. of cement net shall be a barrel.

All cement must bear maker's name and brand on the barrel or package.

Tests.

2. The cement shall stand the following tests made in the City Engineer's Office in accordance with the methods recommended by the Canadian Society of Civil Engineers from time to time.

(a) Cement submitted to chemical analysis shall not contain more than 4 per cent. of magnesia (MgO), nor more than 2 per cent. anhydrous sulphuric acid (SO_3).

(b) Specific gravity of the cement shall not be less than 3.10.

(c) The cement shall be ground so as to leave by weight a residue of not more than 8 per cent. on a No. 100 sieve, and not more than 25 per cent. on a No. 200 sieve.

(d) The cement shall not develop initial set in less than thirty minutes, and must develop hard set in not less than one hour, nor more than ten hours.

(e) The minimum requirements for tensile strength for briquettes one square inch in section shall be as below. They shall show no retrogression in strength within the periods specified.

NEAT CEMENT.

Age.	Strength.
24 hours in moist air	150 lbs.
7 days (1 day in moist air, 6 days in water)	500 lbs.
28 days (1 day in moist air, 27 days in water)	650 lbs.

ONE PART CEMENT, THREE PARTS STANDARD SAND.

7 days (1 day in moist air. 6 days in water) ..... 150 lbs.

28 days (1 day in moist air, 27 days in water) ..... 300 lbs.

(f) Cement shall pass such tests for soundness as may from time to time be recommended by the Canadian Society of Civil Engineers.

Sand. 3. All sand shall be live, clean, sharp and silicious, free from loam, mica or other foreign matter.

Sand used for concrete shall be uniformly graded from coarse to fine, no particle being more than one-eighth (⅛) of an inch in diameter and containing not more than ten (10) per cent. very fine.

Sand used for mortar for brickwork shall be of suitable size and quality.

If necessary, in the opinion of the Engineer, all sand shall be screened or washed and must be equal to the samples submitted to the Engineer, and shall meet with the Engineer's approval before being brought on the work.

Gravel. 4. All gravel shall be hard and of good quality. It shall be free from dirt, loam or other foreign matter, and shall not contain more than 15 per cent. sand. It shall be uniformly graded in size from ¼ inch diameter up to the maximum size specified for the different classes of concrete.

Broken stone 5. All broken stone shall be clean crushed granite, trap or limestone of approved hardness and toughness. It shall be free from all impurities and dust, and be uniformly graded from ¼ inch diameter up to the maximum size specified for the different classes of concrete. It shall be broken into approximately cubical pieces, and be free from long, thin scales.

C. H. RUST,

City Engineer.

B-9-58-500. May 1st, 1911.

CITY OF TORONTO.

General Specifications for Bridges.

APPENDIX.

TABLE I.

WEIGHTS OF MATERIALS.

Material.	Weight per cub. foot in pounds.
Asphalt	150
Brick (Paving)	150
Brick (Common)	125
Concrete	150
Earth	100
Granite	170
Gravel (rammed)	125
Limestone	170
Sand (rammed)	125
Steel	490
Timber (Yellow Pine or Oak)	60
Timber (Red Pine, White Pine or Spruce)	48

TABLE II.

UNIFORM LIVE LOAD FOR TRUSSES.

To be considered as covering the whole or any part of the bridge.

Span in Feet.	Pounds per square foot of remaining surface of roadway. Sidewalks one-half this load.	Pounds per lin. foot for each track assumed to occupy a width of ten feet.
Up to 30	135	2250
40	130	2200
50	125	2150
60	120	2100
70	115	2050
80	110	2000
90	105	1950
100	100	1900
110	98	1850
120	96	1800
130	94	1750
140	92	1700
150	90	1650
160	88	1600
170	86	1550
180	84	1500
190	82	1450
200	80	1400

When the stress in any web-member of the trusses due to the maximum floor beam concentration exceeds that due to the above uniform load, the member shall be designed for the greater stress.

TABLE III.

MAXIMUM MOMENTS, SHEARS AND FLOORBEAM REACTIONS.

Class C Loading (Live Load only.)

Figures for Two Rails.

Span in Feet.	Moment. Ft. Pounds.	Shear. Pounds.	Floorbeam Reaction. Pounds.	Equivalent Uniform Load.		
				Moment.	Shear.	F. B. Reaction
1	5000	20000	20000	40000	40000	20000
2	10000	20000	20000	20000	20000	10000
3	15000	20000	20000	13300	13300	6670
4	20000	20000	20000.	10000	10000	5000
5	25000	20000	20000	8000	8000	4000
6	30000	23333	23333	6700	7770	3900
7	35000	25714	25714	5700	7350	3680
8	40000	27500	27500	5000	6900	3440
9	46900	28890	28890	4600	6420	3210
10	56250	30000	30000	4500	6000	3000
11	65700	30910	32637	4350	5620	2970
12	75200	31667	35000	4200	5280	2920
13	84800	32307	36923	4000	4970	2840
14	94500	32857	38571	3850	4700	2760
15	104200	33333	40000	3700	4440	2670
16	113900	35000	42500	3560	4380	2650
17	123700	36471	44765	3420	4300	2630
18	133472	37778	46667	3300	4200	2590
19	143290	38948	48422	3170	4100	2550
20	153125	40000	50000	3060	4000	2500

TRACK STRINGERS.

Max. Lengths for Standard Beams for LL., DL. and Imp.

8″ I @ 18 lb., 3′ 6′
9″ I @ 21 lb., 5′ 0″
10″ I @ 25 lb., 6′ 6″
12″ I @ 31½ lb., 9′ 0″
12″ I @ 40 lb., 10′ 0″
15″ I @ 42 lb., 12′ 0″
18″ I @ 55 lb., 16′ 6″
20½″ I @ 65 lb., 20′ 0″

DIAGRAM I

MINIMUM CLEARANCE
STEAM RAILWAYS

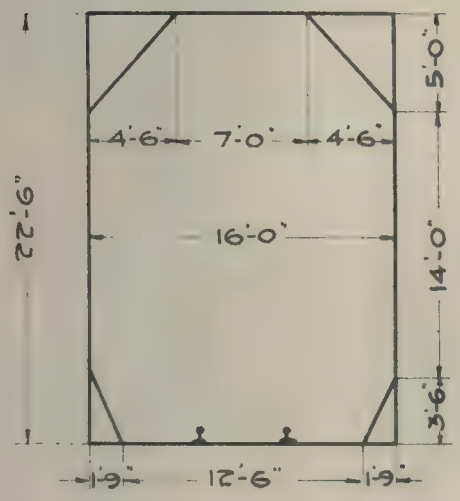

DIAGRAM II.

MINIMUM CLEARANCE
ELECTRIC RAILWAYS

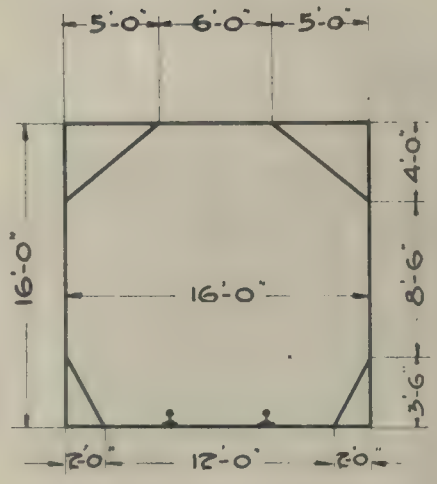

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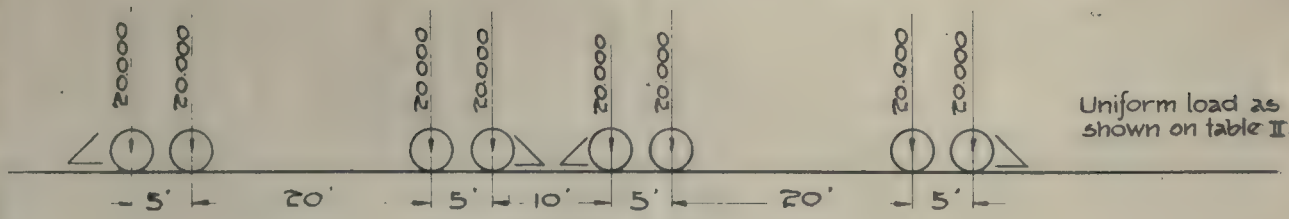
DIAGRAM III.

STANDARD LOADING FOR BRIDGES

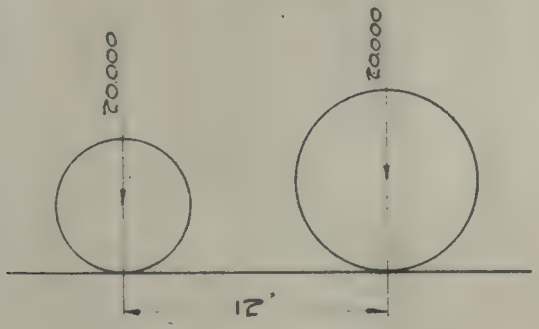
ELECTRIC RAILWAYS



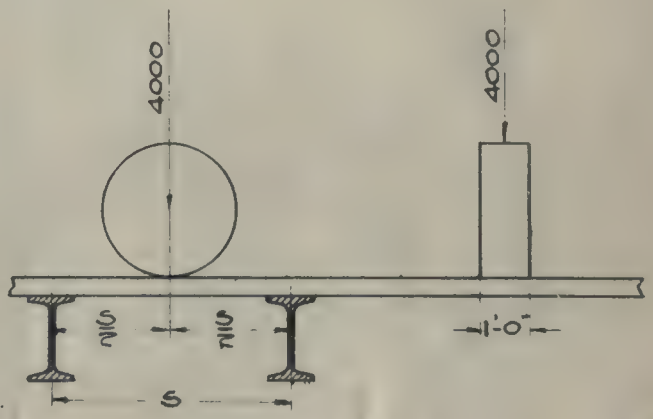
Figures for two rails.

ROAD ROLLER

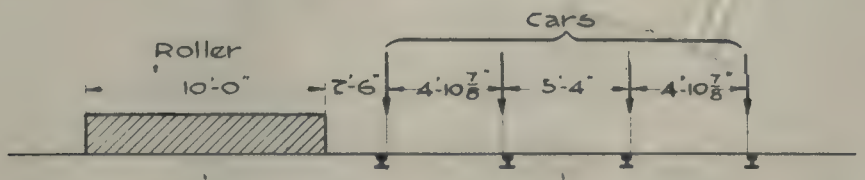
Load to be considered as distributed over a width of 10 feet.



CONCENTRATED WHEEL LOAD FOR FLOORING



POSITION OF LOADS FOR MAXIMUM FLOORBEAM CONCENTRATION



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C. H. Rust
CITY ENGINEER